HIGH-PILED COMBUSTIBLE STORAGE DOCUMENT #1

GENERAL INFORMATION ON THE REQUIREMENTS OF CHAPTER 23 OF THE 2010 California Fire Code

CITY OF RIVERSIDE FIRE DEPARTMENT
Fire Prevention Division

HIGH PILED COMBUSTIBLE STORAGE DOCUMENT SUMMARIES

Document 1 **General Information on the Requirements of Chapter 23 of the 2010 California Fire Code.** This document contains general information about high-piled combustible storage and the requirements of Chapter 23 of the 2010 California Fire Code. This document is recommended for first time customers trying to obtain as much practical information as possible prior to plan submittal. This document also contains samples of our questionnaires for both stocking of general commodities as well as plastics.

Document 2 **Commodity Classifications.** This document contains numerous examples of products and their associated commodity classifications. Use this document to aid in correctly determining the commodity class for a given product or products.

PURPOSE

This document will provide the user a basic understanding of high pile storage requirements as found within Chapter 23 of the 2010 California Fire Code. The document will also describe high pile storage plan submission requirements, and discuss some examples and problem areas concerning high pile storage.

SCOPE

This document applies to all facilities engaging in high pile storage activities. High pile storage activities include any and all activities in which combustible materials with a commodity classification of 1 through 4 are stored over 12 feet in height. It also includes any and all activities in which combustible materials with a high hazard commodity classification are stored over 6 feet in height.

Storage practices of any kind regarding non-combustible materials are not within the scope of this document. Additionally, the high pile storage of hazardous materials is outside the scope of this document.

DEFINITIONS

AEROSOL A product which is dispensed from a pressurized aerosol container by the use of a propellant. (CFC)

AREA CAPABLE OF ACCOMMODATING HIGH PILE STORAGE Buildings containing an area capable of accommodating high pile storage, but which is not being utilized as such. (CFC)

ARRAY The configuration of storage. Characteristics considered in defining an array include the type of packaging, flue spaces, height of storage and compactness of storage. (CFC)

ARRAY, CLOSED A storage arrangement having a 6-inch or smaller width vertical flue space that restricts air movement through the stored commodity. (cFC, NFPA 13)

ARRAY, OPEN A storage arrangement where air movement through the pile is enhanced because of vertical flues larger than 6-inches. (NFPA 13)

AUTOMATED STORAGE AND RETRIEVAL SYSTEM An Automatic Storage and Retrieval System is an automated, robotic system for sorting, storing and retrieving items in a warehouse. (About.com)

BIN BOX A five-sided container with an open side facing an aisle. Bin boxes are self-supporting or are supported by a structure designed so that little or no horizontal or vertical space exists around the boxes. (CFC)

CARTONED A method of storage consisting of corrugated cardboard or paperboard containers fully enclosing the commodity. (NFPA 13)

COMBUSTIBLE A material that, in the form in which it is used and under the conditions anticipated, will ignite and burn. A material that does not meet the definition of non-combustible. (NFPA 101)

COMBUSTIBLE, NON A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion or release flammable vapors when subjected to heat. (NFPA 13)

COMBUSTIBLE, ORDINARY Commodities consisting of wood, paper, natural fibers, etc.

COMMODITIES The combinations of product, packing material and container upon which commodity classifications are based. (CFC)

CURTAIN BOARDS or DRAFT CURTAINS Structures arranged to limit the spread of smoke and heat along the underside of the ceiling or roof. (CFC)

EARLY SUPPRESSION FAST RESPONSE SPRINKLERS (ESFR) A type of fast response sprinkler that meet the criteria of having a thermal element with an RTI of 80 (meter-seconds)$^{1/2}$ or more, and is listed for its capability to provide fire suppression of specific high-challenge fire hazards. (NFPA 13)

ENCAPSULATED A method of packaging consisting of a plastic sheet completely enclosing the sides and top of a pallet load containing a combustible commodity, a combustible package, a group of combustible commodities or combustible packages. Totally noncombustible commodities on wood pallets enclosed only by a plastic sheet, as described, are not covered under this definition. *Banding* (i.e. stretch-wrapping around the sides only of a pallet load) is not considered to be encapsulated. Where there are holes or voids in the plastic or waterproof cover on the top of the carton that exceed more than half of the area of the cover, the term encapsulated does not apply. The term encapsulated does not apply to plastic-enclosed products or packages inside a large, non-plastic, enclosed container. (NFPA 13)

EXTRA HIGH-RACK COMBUSTIBLE STORAGE Storage on racks of Class I, II, III, or IV commodities which exceed 40-ft in height and storage on racks of high-hazard commodities which exceed 30-ft in height. (CFC)

FLUE SPACE, LONGITUDINAL The space between rows of storage perpendicular to the direction of loading. (NFPA 13)

FLUE SPACE, TRANSVERSE The space between rows of storage parallel to the direction of loading. (NFPA 13)

HIGH PILED COMBUSTIBLE STORAGE Storage of combustible materials in closely packed piles or combustible materials on pallets, in racks, or on shelves where the top of storage is greater than 12 feet in height. When required by the fire code official, high-piled combustible storage also includes certain high-hazard commodities, such as rubber tires, Group A plastics, flammable liquids, idle pallets, rail-road ties and similar commodities, where the top of storage is greater than 6 feet in height. (CFC)

HIGH PILE STORAGE AREA An area within a building which is designated, intended, proposed or actually used for high pile combustible storage. This definition is intended to include the actual floor space of racks or piles, and associated aisles, when required. (CFC)

PALLETS Material-handling aids, constructed of wood or plastic, designed to support unit loads, with openings to provide access for material handling devices. (NFPA 13)

PALLET, SLAVE A specifically designed pallet to be used with a computerized material handling system. (NFPA 13)

PILE, STABLE Those arrays where collapse, spillage of contents, or leaning of stacks across flue spaces is not likely to occur soon after initial fire development. (NFPA 13)

PILE, UNSTABLE Those arrays where collapse, spillage of contents, or leaning of stacks across flue spaces occurs soon after initial fire development. (NFPA 13)

PLASTICS, GROUP A Group A plastics are plastic materials having a heat of combustion that is much higher than that of ordinary combustibles, and a burning rate higher than that of Group B plastics. (CFC)

PLASTICS, GROUP B Group B plastics are plastic materials having a heat of combustion and a burning rate higher than that of ordinary combustibles, but not as high as those of Group A plastics. (CFC)

PLASTICS, GROUP C Group C plastics are plastic materials having a heat of combustion and a burning rate similar to those of ordinary combustibles. (CFC)

PLASTICS, FREE-FLOWING Those plastics that, in their original state of flakes, powder, pellets, or random-packed small plastic objects (ex: razor blade dispensers), will fall out of their containers during a fire, fill the flue spaces, and create a smothering effect on a fire. (NFPA 13)

PLASTICS, EXPANDED (FOAMED OR CELLULAR) Those plastics, the density of which is reduced by the presence of numerous small cavities (cells), interconnecting or not, dispersed throughout their mass. (CFC, NFPA 13)

PLASTICS, NON EXPANDED Those plastics with high densities, solid, or not otherwise categorized as expanded, such as polyethylene film, polystyrene toys, polyester and polystyrene plastic tote bins, polyethylene 55-gallon drums or smaller containers, etc.

RACK Any combination of vertical, horizontal, and diagonal members which supports stored materials. Some rack structures use solid shelving. Racks can be fixed, portable, or moveable. Loading can be either manual, using lift trucks, stacker cranes, hand placement or automatic, using machine controlled storage and retrieval systems. (NFPA 13)

RACK, SINGLE ROW Racks with no longitudinal flue space, and having a width up to 6 feet, with aisles at least 3½ feet from other storage. (NFPA 13)

RACK, DOUBLE ROW Two single row racks placed back to back, creating a flue space, having a combined width up to 12 feet, with aisles at least 3½ feet on each side. (NFPA 13)

RACKS, MULTIPLE-ROW Racks greater than 12 feet wide or single- or double-row racks separated by aisles less than 3½ feet wide, having an overall width greater than 12 feet. (NFPA 13)

RACKS, PORTABLE Racks that are not fixed in place. They can be arranged in any number of configurations. (NFPA 13)

RACKS, MOVEABLE Racks on fixed rails or guides. They can be moved back and forth only in a horizontal two-dimensional plane. A moving aisle is created as abutting racks are loaded or unloaded, then moved across the aisle to abut other racks. Rack arrangements generally result in the same protection needs as for multi-row racks. (NFPA 13)

SOLID SHELVING Fixed-in-place solid, slatted or other types of shelves, located within the racks, and which obstructs sprinkler discharge down into the racks. The area of a solid shelf is defined by perimeter aisle or flue space on all four sides. Solid shelves having an area equal or less than 20 square feet shall be defined as open racks. Shelves of wire mesh, slates or other materials more than 50 percent open, and where the flue spaces are maintained, shall be defined as open racks. (CFC, NFPA 13)

STORAGE, BIN BOX Storage in five-sided wood, metal or cardboard boxes with open face on the aisles. Boxes are self supporting or supported by a structure so designed that little or no horizontal or vertical space exists around boxes. (NFPA 13)

STORAGE, HEIGHT The measurement between the finished floor and top of the stored commodity. This is not to mean the measurement taken to the top of the highest shelf on the rack or other storage systems. (FM 8-9)

STORAGE, PALLETIZED Storage of commodities on pallets or other storage aids that form horizontal spaces between tiers of storage. (NFPA 13)

STORAGE, RACK Storage in racks that use combinations of vertical, horizontal and diagonal members, with or without solid shelves, to support stored material. Racks may be fixed in place or portable. Loading may be done either manually by using lift trucks, stacker cranes, or hand placement, or automatically by using machine-controlled storage and retrieval systems. (FM 8-9)

STORAGE, SHELF Storage on a structure where shelves are less than 30 inches deep with the distance between shelves usually 2 feet apart and not exceeding 3 feet vertically, and separated by approximately 30 inches. (CFC, NFPA 13)

STORAGE, SOLID PILE This is on-floor storage, without pallets or other material handling devices. Unit loads are placed on top of each other, leaving no horizontal spaces between unit loads. (FM 8-9)

GUIDELINES

PLANS, FEES, INSPECTIONS AND PERMITTING

Plans. High pile storage plans are required for all high pile storage buildings/facilities, or high pile storage arrangements within buildings, with the following scenario:

501 square feet or greater of Class I-IV and High Hazard commodity storage.

It is important to note that all storage areas within the building contribute to this square footage for the purposes of submitted plans. This is regardless of whether the storage areas are adequately separated, which is discussed later in this document. In other words, the total storage of all storage areas, regardless of separation, is added together and if they meet one or more of the above criteria, plans must be submitted for review.

For example, a building has four high pile storage areas with each storage area totaling 700 square feet of Class IV commodities. The cumulative square footage is 2800 square feet of Class IV commodities. Therefore high pile storage plans are required to be submitted. The submission requirements for these plans are discussed later in this document.

Plan submittal requirements. Required plans must be provided with the following information:

- ☐ Project name and address shown on plans
- ☐ High piled storage application attached to plans
- ☐ Floor plan of the building showing locations and dimensions of all high-piled storage areas
- ☐ Usable storage height for each storage area
- ☐ Indications as to rack storage areas and/or pile storage areas
- ☐ Location and classification of commodities for all storage areas
- ☐ Maximum pile volume for each storage array
- ☐ Dimension and location of transverse and longitudinal flue spaces
- ☐ Aisle dimensions between each storage array
- ☐ Usable storage height for each storage area
- ☐ Location of required fire department access doors
- ☐ Number of tiers within each rack
- ☐ Location of commodities which are banded or encapsulated
- ☐ Type of fire suppression and detection equipment
- ☐ Commodity clearance between top of storage and the sprinkler deflector for each storage arrangement
- ☐ Type, location and specifications of smoke removal and curtain board systems
- ☐ Additional information regarding required design features, commodities, storage arrangement and fire protection features within the high-piled storage area

Three sets of plans shall be submitted to the Fire Prevention Bureau.

Fees. Fees are required for all plans reviewed. The fees also cover associated inspections. Fees for high piled storage are based on a 30 minute or longer review. Please contact the Fire Prevention Division for the latest fee schedule.

Inspections. As previously stated, the cost of all inspections is included within the fees. A facility is ready for inspection once the plans have been reviewed and approved, and plan review fees have been paid. Then all stock must be moved into the building and all high pile storage requirements must be in place, although the building has not opened for business. Note that the ability to move stock into the building for the high pile inspection is dependent upon Fire and Building Inspector approval. Contact the Fire Prevention Division with any inspection scheduling concerns or questions. Fire Prevention may be reached by calling 951-826-5737.

PERMITS. After inspection, a high piled storage permit is issued.

Annually, a high piled storage certification form shall be submitted for storage verification. If arrangements or commodities have changed, a new application will be required to be submitted.

GENERAL REQUIREMENTS

Commodity Classification. The single most important factor within high pile storage is the accurate determination of the classification of the commodities being stored. All high pile storage requirements, as well as fire sprinkler design parameters, are based on the commodity classifications of the products stored. *RFD High Pile Combustible Storage Document 2 - Commodity Classifications*, provides a comprehensive list of commodities and their associated classifications. Refer to this document for determining commodity classifications. For any specific questions regarding commodity classification, please contact the Fire Prevention Division.

Limited quantities of Group A plastics. The fire code allows a limited amount of Group A plastics within any commodity classification without increasing the commodity classification. The fire code provides a graph that enables users to determine whether or not the amount of Group A plastics will cause the commodity classification to increase. In order to determine what the final commodity classification is, a minimum of two out of three data points are necessary. Either the percent by volume of expanded plastic or percent by weight of expanded plastic, and percent by weight of unexpanded plastic, are needed. The issue is how to determine these numbers. Figure 1 shows a table from the 2010 CFC that is used to determine these numbers.

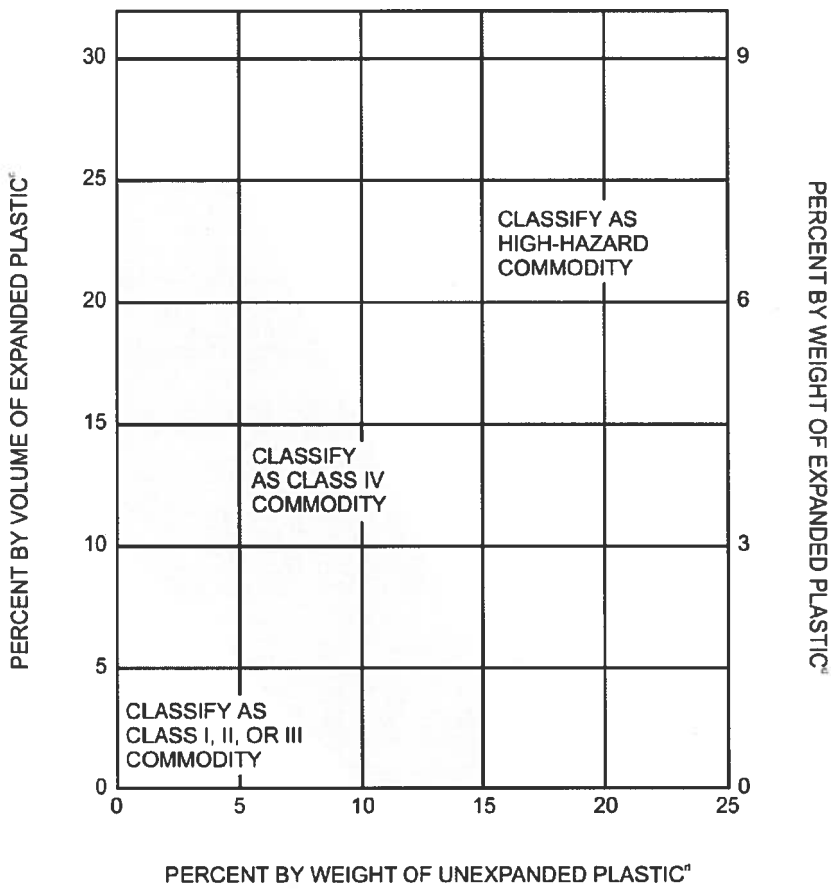


FIGURE 1 - FIGURE 2303.7.4 IN THE 2010 CFC AS AMENDED

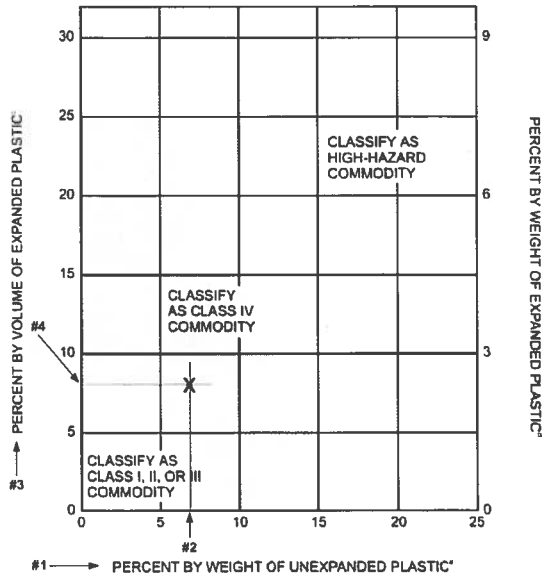
The following formulas are used to determine the amounts of plastics within a commodity.

Percent by volume = $\frac{\text{Volume of plastic in pallet load}}{\text{Total volume of pallet load, including pallet}}$

Percent by weight = $\frac{\text{Weight of plastic in pallet load}}{\text{Total weight of pallet load, including pallet.}}$

The formulas are based on an individual pallet or carton load. This means that the entire pallet or carton must be considered in determining the amount of plastics. The following examples help explain this further.

Example #1
Given:



A commodity contains 7 percent by weight of unexpanded Group A plastic and 8 percent by volume of expanded plastic. What is the commodity classification?

Solution:

- Find percent by weight of unexpanded plastic on chart (#1 in Figure 2)
- Find where 7 percent would fall along this axis and draw an imaginary line vertically (#2 in Figure 2)
- Find percent by volume of expanded plastic on the chart (#3 in Figure 2)
- Find where 8 percent would fall along this axis and draw an imaginary line horizontally (#4 in Figure 2)
- Where the lines intersect correlate with a commodity classification

Answer: Since the intersection point is within the shaded area identified as Class IV commodity, the commodity shall be classified as such.

FIGURE 2 - EXAMPLE 1 ILLUSTRATION

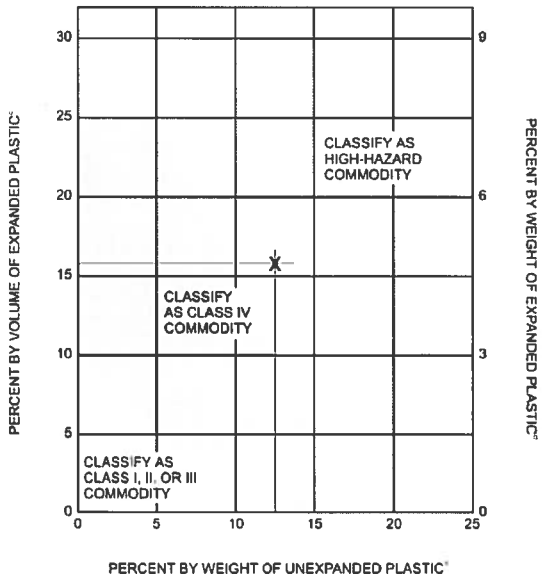
Example #2
Given:
A pallet load of 20 scanners has the following dimensions and weights:

- Dimension of pallet load is 4 feet by 4 feet
- Each scanner has 0.5 cubic feet of polystyrene foam packaging
- Entire pallet load weighs 400 pounds
- Each scanner has 2.5 pounds of Group A nonexpanded plastic (rubber rollers, ABS cover, etc.) with remainder of weight load being other than Group A plastics

What is the commodity classification?

Solution:

- 0.5 cubic feet of foam packaging per scanner multiplied by 20 scanners = 10 cubic feet
- 4 feet x 4 feet x 4 feet - 64 cubic feet for the entire pallet load
- THEREFORE, 10 cubic feet divided by 64 cubic feet multiplied by 100 percent equals 15.6% by volume of expanded plastic ((10cf / 64cf) x 100% = 15.6%)
- 2.5 pounds of unexpanded Group A plastic per scanner multiplied by 20 scanners equals 50 pounds of unexpanded Group A plastic. (2.5lbs x 20 = 50lbs.)
- THEREFORE, 50 pounds divided by 400 pounds multiplied by 100 percent equals 12.5% by weight of unexpanded Group A plastics. ((50lbs/400lbs) x 100% = 12.5%)



Answer:
Using the same steps in Example 2, the commodity classification, based on the amount of Group A plastics is High Hazard. See Figure 3.

Separation of high pile storage areas. When required, high pile combustible storage areas must be separated from other portions of the building. Some examples of this include separation between uses, multiple storage areas and storage areas with varying commodity classifications. Each will be discussed.

Separation from other uses. The California Fire Code references the California Building Code for occupancy separation for mixed occupancies. Chapter 3, and more specifically, Table 302.3.2 *Required Separation of Occupancies* of the 2010 CBC, require adequate separation between occupancies within a building. Ensure that any storage areas and their associated occupancy classifications are adequately separated per this Chapter and Table.

Aggregate areas. For the purposes of determining requirements within Chapter 23, when multiple storage areas are proposed, the square footages for all storage areas must be added together. See Figure 4. If storage areas are adequately separated, then each storage area may be considered individually, as shown in Figure 5. Remember, plans are required when high pile combustible storage totals more than 500 square feet. This is regardless if storage areas are separated. Assuming the storage areas are identical occupancy (not commodity) classifications, the CFC requires the separation to consist of a 1-hour rated fire barrier wall and any/all openings to be protected with 1-hour rated assemblies. Provisions within the CBC allow 3/4-rated assemblies within 1-hour rated fire barriers. This common practice is not permitted for the purposes of Chapter 23 of the CFC. Minimum 1-hour rated fire assemblies are required within 1-hour rated fire barriers.

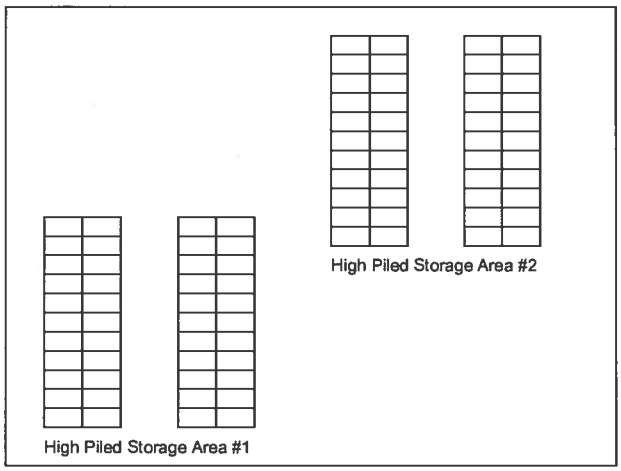


FIGURE 4 - NON-SEPARATED STORAGE AREAS

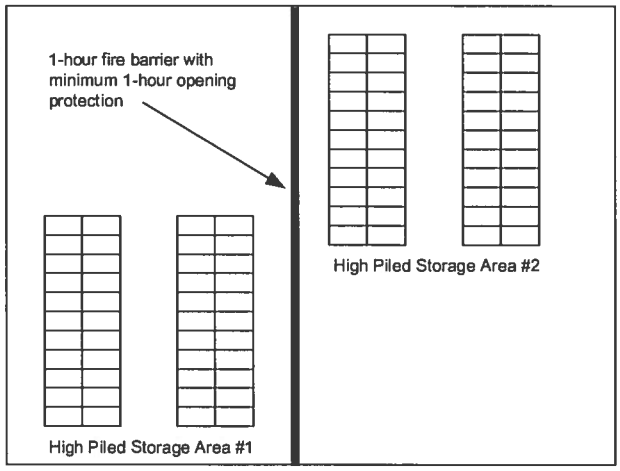


FIGURE 5 - SEPARATED STORAGE AREAS

Multi-class storage areas. When a facility utilizing more than one storage area has at least one of those storage areas consisting of high hazard commodities, with the remainder of the storage areas Class IV or lower commodities, those storage areas must be separated. Otherwise, all storage areas must be designed per High Hazard requirements, regardless of the storage areas' proximity to each other. The required separation is the minimum 1-hour fire barrier and 1-hour fire rated assemblies, as previous discussed. This does not necessarily mean that each storage area must be separated from all of the others; it means that if the storage area storing high hazard commodities is not adequately separated from the others, then all storage areas are processed at the high hazard commodity classification. This will be discussed in more detail later in this document.

General Fire Protection and Life Safety Requirements. Based on the commodity classifications of the products stored and the square footage(s) of the storage areas, certain provisions are required as per Table 2306.2, *General Fire Protection and Life Safety Requirements.* Table 2306.2 is provided below for reference.

COMMODITY CLASS	SIZE OF HIGH-PILED STORAGE AREA[a] (square feet) (see Sections 2306.2 and 2306.4)	ALL STORAGE AREAS (See Sections 2306, 2307 and 2308)[b]					SOLID-PILED STORAGE, SHELF STORAGE AND PALLETIZED STORAGE (see Section 2307.3)		
		Automatic fire-extinguishing system (see Section 2306.4)	Fire detection system (see Section 2306.5)	Building access (see Section 2306.6)	Smoke and heat removal (see Section 2306.7)	Draft curtains (see Section 2306.7)	Maximum pile dimension[c] (feet)	Maximum permissible storage heightd (feet)	Maximum pile volume (cubic feet)
I-IV	0-500	Not Required[a]	Not Required	Not Required[e]	Not Required	Not Required	Not Required	Not Required	Not Required
	501-2,500	Not Required[a]	Yes[i]	Not Required[e]	Not Required	Not Required	100	40	100,000
	2,501-12,000 Public accessible	Yes	Not Required	Not Required[e]	Not Required	Not Required	100	40	400,000
	2,501-12,000 Nonpublic accessible (Option 1)	Yes	Not Required	Not Required[e]	Not Required	Not Required	100	40	400,000
	2,501-12,000 Nonpublic accessible (Option 2)	Not Required(a)	Yes	Yes	Yes(j)	Yes(j)	100	30(f)	200,000
	12,001-20,000	Yes	Not Required	Yes	Yes[j]	Not Required	100	40	400,000
	20,001-500,000	Yes	Not Required	Yes	Yes[j]	Not Required	100	40	400,000
	Greater than 500,000[g]	Yes	Not Required	Yes	Yes[j]	Not Required	100	40	400,000
High hazard	0-500	Not Required[a]	Not Required	Not Required[e]	Not Required	Not Required	50	Not Required	Not Required
	501-2,500 Public accessible	Yes	Not Required	Not Required[e]	Not Required	Not Required	50	30	75,000
	501-2,500 Nonpublic accessible (Option1)	Yes	Not Required	Not Required[e]	Not Required	Not Required	50	30	75,000
	501-2,500 Nonpublic accessible (Option 2)	Not Required(a)	Yes	Yes	Yes(j)	Yes(j)	50	20	50,000
	2,501-300,000	Yes	Not Required	Yes	Yes[j]	Not Required	50	30	75,000
	300,001-500,000[g, h]	Yes	Not Required	Yes	Yes[j]	Not Required	50	30	75,000

For SI: 1 foot = 304.8 mm, 1 cubic foot = 0.02832 m^3, 1 square foot = 0.0929 m^2.

a. When automatic sprinklers are required for reasons other than those in Chapter 23, the portion of the sprinkler system protecting the high-piled storage area shall be designed and installed in accordance with Sections 2307 and 2308.

b. For aisles, see Section 2306.9.

c. Piles shall be separated by aisles complying with Section 2306.9.

d. For storage in excess of the height indicated, special fire protection shall be provided in accordance with Note g when required by the fire code official. See also Chapters 28 and 34 for special limitations for aerosols and flammable and combustible liquids, respectively.

e. Section 503 shall apply for fire apparatus access.

f. For storage exceeding 30 feet in height, Option 1 shall be used.

g. Special fire protection provisions including, but not limited to, fire protection of exposed steel columns; increased sprinkler density; additional in-rack sprinklers, without associated reductions in ceiling sprinkler density; or additional fire department hose connections shall be provided when required by the fire code official.

h. High-piled storage areas shall not exceed 500,000 square feet. A 2-hour fire wall constructed in accordance with the *International Building Code* shall be used to divide high-piled storage exceeding 500,000 square feet in area.

i. Not required when an automatic fire-extinguishing system is designed and installed to protect the high-piled storage area in accordance with Sections 2307 and 2308.

j. Not required when storage areas are protected by early suppression fast response (ESFR) sprinkler systems installed in accordance with NFPA 13.

Automatic fire extinguishing systems. Chapter 23 only states when a fire sprinkler system is required. Chapter 23 does not state which type of fire sprinkler system is required. It is beyond the scope of Chapter 23 and this document to discuss fire sprinkler systems and high pile storage, other than to note in the table above when a fire sprinkler system is required.

Fire detection systems. Another important amendment is the elimination of any requirement for fire detection systems. Previously, fire detection systems were permitted in lieu of fire sprinkler systems and other provisions when specific-sized storage areas were considered non-accessible to the public. As with

fire sprinkler systems, it is beyond the scope of Chapter 23 and this document to discuss fire alarm systems, other than what has been previously discussed.

Building access. When required, access doors that lead directly into the high pile storage areas are to be installed. These doors must be keyed for fire department use, which means that all doors must be keyed such that one key may open any of the doors, and that key must be provided in the building's Knox™ lock box. These keys must also be labeled for their use. The access doors shall not be less than 3 feet in width and 6 feet, 8 inches in height. The use of a ladder to access the doors is prohibited, and utilizing roll-up doors as the access doors are not permitted.

Access doors are required for each 100 lineal feet, or fraction thereof, of storage area exterior walls that front fire apparatus access roads. This means that if an office and warehouse with high pile storage fronts a fire apparatus access road, and the total length of the warehouse portion fronting the access road is 250-feet, a total of 3 access doors are required. Again, one door is required for each 100 lineal feet or fraction thereof. There are two 100-foot segments, plus one, fraction of a 100-foot segment; hence, 3 access doors. These access doors may be located at any point along each 100-foot lineal section. This means that the doors could be as close as a few feet apart, to as many as 200-feet apart. As long as at least one door is provided for each 100-ft lineal section of an exterior wall of a high pile storage area that fronts a fire department access road, the intent of the code is met. See Figure 6 for an illustration of this. If fire apparatus access roads are provided along either side and/or back of this example, additional doors would then be required.

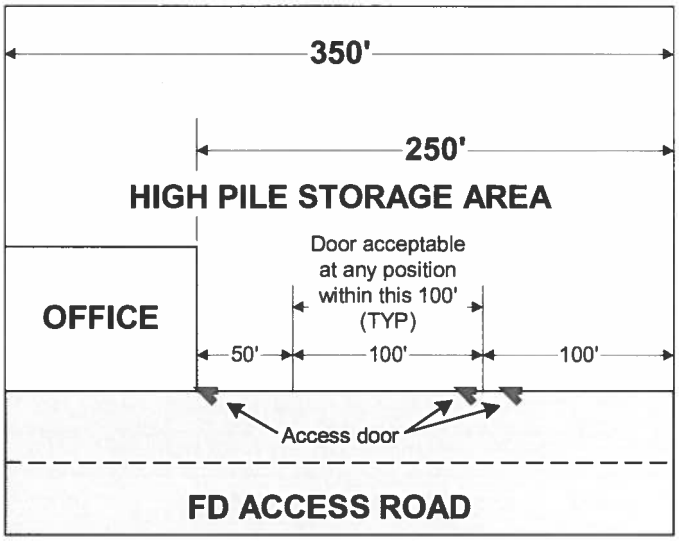


FIGURE 6 - ACCESS DOOR REQUIREMENT AND LOCATION EXAMPLE

Smoke and heat vents. Smoke and heat vents are required as dictated by Table 2306.2. The Fire Prevention Division is well aware of studies performed that suggest smoke/heat vents interfere with the designed operation of fire sprinklers. Despite these studies, smoke/heat vents are still required. However, when vents are provided in buildings that utilize fire sprinklers, the fusible element of the vent must be at least 100° F above the operating temperature of the sprinklers within immediate vicinity of the vent. Therefore, if the temperature rating of the sprinklers is 286° F, the fusible element of the vents must be at least 386° F. This is to help ensure that the sprinklers operate as designed and are minimally affected by vent operation. Additionally, the Riverside City Fire Department does not utilize the vents as an automatic fire protection feature of a building. Although the vents will operate automatically, the intent with the vent use is to allow ease in manual venting and to reduce the chance of firefighters having to cut a hole in a roof to vent it. Firefighters would be able to open vents strategically to evacuate smoke and heat. Due to this, all smoke and heat vents must open automatically as well as have approved means of

manual opening from the roof. All vents must be labeled, both inside and out, in a logical manner. The labeling scheme must be indicated on the plans.

With that said when a building employs an ESFR sprinkler system or an "Early Suppression Fast Response" sprinkler system, the requirement for smoke/heat vents may be eliminated. This provision is found in Footnote "J".

Smoke vent calculation. To determine the number of required smoke/heat vents, Table 910.3 of the CFC is utilized.

TABLE 1 - TABLE 910.3 OF THE 2010 CFC

REQUIREMENTS FOR DRAFT CURTAINS AND SMOKE AND HEAT VENTS

OCCUPANCY GROUP AND COMMODITY CLASSIFICATION	DESIGNATED STORAGE HEIGHT (FEET)	MINIMUM DRAFT CURTAIN DEPTH (FEET)	MAXIMUM AREA FORMED BY DRAFT CURTAINS (SQ. FT.)	VENT-AREA-TO FLOOR-AREA RATIO(c)	MAXIMUM SPACING OF VENT CENTERS	MAXIMUM DISTANCE FROM VENTS TO WALL OR DRAFT CURTAIN(b) (FEET)
Group F-1 and S-1	-	0.2xHd but ≥4	50,000	1:100	120	60
High-piled storage (see Section 910.2.2) Class I-IV Commodities (Option 1)	≤20	6	10,000	1:100	100	60
	≥20≤40	6	8,000	1:75	100	55
High-piled storage (see Section 910.2.2) Class I-IV Commodities (Option 2)	≤20	4	3,000	1:75	100	55
	≤20≤40	4	3,000	1:50	100	50
High-piled storage (see Section 910.2.2) High Hazard Commodities (Option 1)	≤20	6	6,000	1:50	100	50
	≥20≤30	6	6,000	1:40	90	45
High-piled storage (see Section 910.2.2) High Hazard Commodities (Option 1)	≤20	4	4,000	1:50	100	50
	≥20≤30	4	2,000	1:30	75	40

The table provides a vent area to floor area ratio based on the commodity classification and height of storage. Therefore, four things are needed to calculate the number of vents required. 1- Commodity classification; 2- Height of storage; 3- Total square footage of storage area; 4- Proper vent ratio.

With the above information, different vent ratios may be chosen. Typically, the ratio that allows the smallest total vent space is chosen. In this example we use the vent ratio of 1:75 (the larger the number, the smaller the total vent space required). With this vent ratio, the total vent square footage may be calculated. The formula to figure the total vent space is as follows:

Storage square footage divided by the vent ratio = total vent square footage

Therefore, 63500 (storage SF) / 75 (vent ratio) = 846.7sf of vents required. Now that the total vent space is known, the number of vents required may be calculated. Note that the number of vents is based on the individual size of the vents being installed. The typical vent size is 4' x 8' (32sf total) and will be used in this example. Therefore, to determine the total number of vents, divide 846.7 by 32. This results in 26.4 vents required. When the number of vents calculated includes a fraction (number right of decimal) the number must be rounded up to the next whole number. For this example, the total number of vents required is 27 vents.

Solid pile storage. There are three typical methods of storage that include solid pile, shelf and rack storage. A significant difference between the solid piles and shelf/rack storage is that the shelves/racks are typically secured to the floor. Solid piles of combustibles are not secured to the floor and the areas they occupy may be expanded, contracted or moved at any time. Because of this, all storage pile areas are required to indicate the boundaries for the piled storage. This may be done with paint, tape or other approved striping on the warehouse floor. There are no requirements as to the color or width of the striping, other than it must be present. However, yellow tape and/or paint has typically been used to delineate these areas.

Hazardous materials storage. The storage of hazardous materials must be in compliance with all applicable fire code and national standards. Refer to applicable codes and national standards for additional information. For specific questions regarding hazardous materials storage, contact the Fire Prevention Division.

PUTTING IT ALL TOGETHER - HIGH PILE STORAGE EXAMPLES

Single storage area, Class I through IV commodities. For a single storage area, there are no differences in requirements between Classes I through IV commodities. Therefore, as an example, if sprinklers are required for a Class II commodity, based on a given amount of storage space, sprinklers will also be required for Class I, III or IV for that same amount of storage space. However, it may be possible to separate the storage by approved methods such that the smaller storage area sizes fall below sizes for requirements. These types of storage areas are the easiest to design. The differences in commodity classifications would play a role in the sprinkler system design, if applicable.

Multiple storage areas, Class I through IV commodities. There may be instances in which a facility wishes to store a specific commodity classification in a specific area. The code allows this practice. Additionally, if the individual storage areas are adequately separated, as previously mentioned, each storage area, not the aggregate of the areas, is required to meet high pile storage requirements. This means that if designed properly, each storage area may not require sprinklers, smoke/heat vents and access provisions. See Figure 7 for an illustration of this.

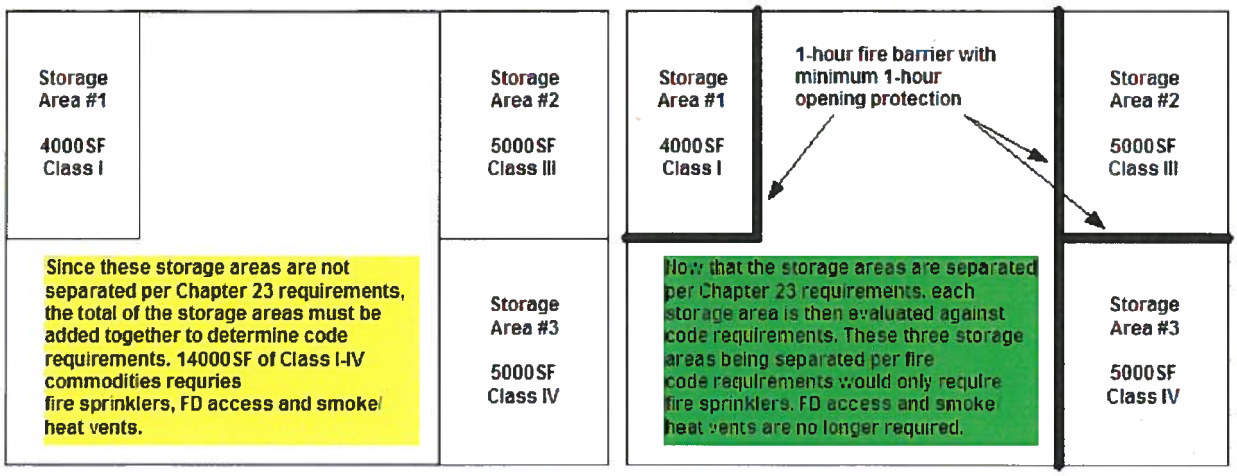


FIGURE 7 - EXAMPLE OF SEPARATED AND NON SEPARATED STORAGE AREAS AND APPLICABLE REQUIREMENTS

Now that the storage areas are separated per Chapter 23 requirements, each storage area is then evaluated against code requirements rather than all areas combined. These three storage areas being separated per fire code requirements would only require fire sprinklers. FD access and smoke/heat vents are no longer required.

Multiple storage areas, Class I through IV and high hazard commodities. High hazard commodities present unique concerns with high pile storage design. This is due to the fact that high hazard commodities burn more intensely than Class I-IV commodities. Therefore are defined as combustibles stored greater than 6 feet (Class I-IV is combustibles over 12 feet), and requirements for fire sprinklers, smoke/heat vents and FD access begin at smaller sizes of storage areas. See Table 2306.2. So the principles of aggregation and separation play a particular role. A facility may have 1,000SF of high hazard commodities with the rest of a 100,000SF being Class IV commodities or less. However, if the high hazard commodities are not separated per code, the entire facility is considered a high hazard commodity.

As an example, a facility currently has one storage area with a total of 17,500SF of mixed commodity storage (12,000Sf of Class I-IV and 2,500SF of high hazard) to 19 feet in height. The facility is bound by a fire apparatus access road on three sides. Being a single storage area, the entire area must meet the requirements of the greatest hazard. In this instance it is high hazard commodities. Therefore 17,500SF of high hazard storage requires 11 smoke/heat vents, 4 FD access doors and fire sprinkler system designed for the high hazard commodity. See Figure 8 below.

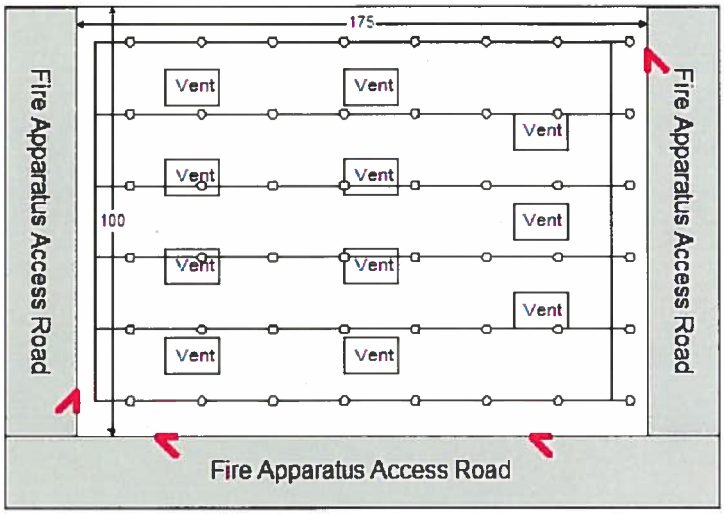


FIGURE 8 - MULTI-COMMODITY NON-SEPARATED STORAGE AND APPLICABLE REQUIREMENTS

The total cost of the sprinkler system, access doors and vents could be significant in the budget for this project. However, if the storage was rearranged such that the high hazard commodities were separated, per fire code requirements, from the remaining commodities, the requirements in Chapter 23 are reduced. The only requirement for high pile storage facilities with 2500SF of high hazard and 12,000SF of Class I-IV commodities that are separated per fire code requirements is a sprinkler system. Therefore, the costs for the vents and access doors are eliminated for the cost of a 1-hour fire barrier and 1-hour opening protection. See Figure 9.

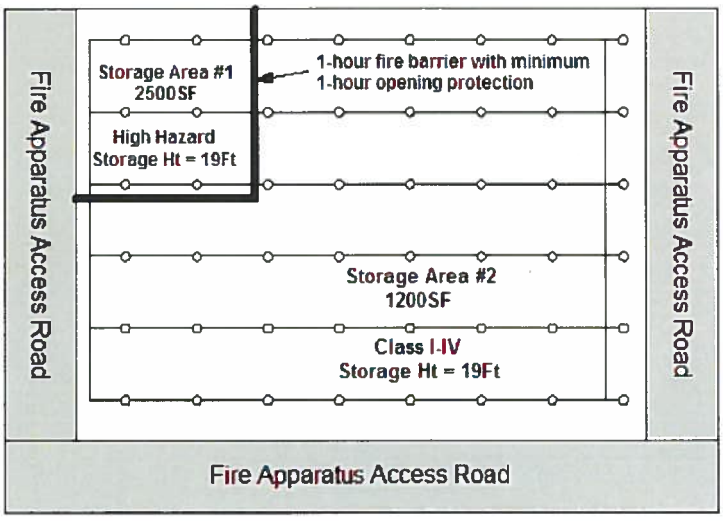


FIGURE 9 - MULTI-COMMODITY SEPARATED STORAGE WITH APPLICABLE REQUIREMENTS

Facilities Capable of High Pile Storage But Not Practicing High Pile Storage

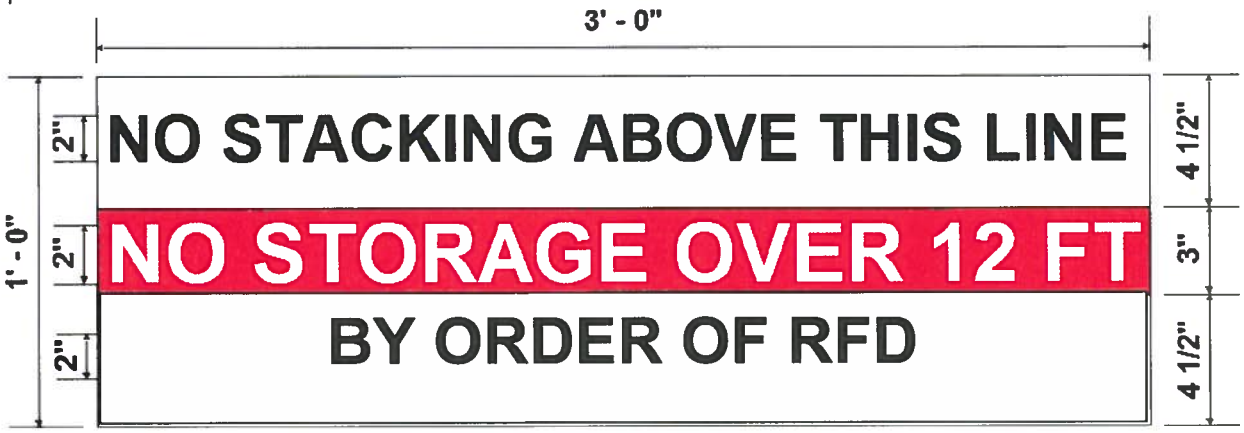
From time to time, a building is designed such that ceiling heights are tall enough to allow storage meeting the definition of high pile combustible storage. However, the facility does not employ such storage practices. These are considered facilities that are capable of, but not practicing, high pile storage. When a facility falls into this category, a high pile storage waiver is required to be signed and placed on file within the Division of the Fire Marshal. This waiver is a declaration signed by the owner of the building that high pile storage of combustible materials will not be practiced in the building. The declaration also states that if such practices are found, during an inspection or at any other time, the

facility must revert back to non high pile practices, or the building or facility must come into full compliance with the current fire code.

Approved signage is required throughout all areas within a building capable of, but not practicing, high pile storage. Spaces such as atriums, with vaulted ceilings (as in churches), auditoriums and other similar spaces are not applicable to this requirement. See the section on *Signage Construction and Design Requirements* for the required signage in these locations. If there is any uncertainty if signage is required in such a space, contact the Division of the Fire Marshal for clarification.

SIGNAGE CONSTRUCTION AND DESIGN REQUIREMENTS

All high pile storage facilities. All signage shall be a minimum of 1 foot by 3 feet and shall be constructed of durable materials such as metal or plastic. Signs constructed of paper, cardboard or similar materials are not acceptable. Each sign shall be provided with "NO STACKING ABOVE THIS LINE" and "BY ORDER OF THE RFD" wording in 2 inch black letters with at least a 1/2 inch stroke on a white background. Additionally, each sign shall be provided with a 3 inch wide red stripe the full width of the sign. Within this red stripe, the maximum height permitted and highest commodity classification (if applicable) shall be stated in 2 inch white letters with at least a 1/2 inch stoke. All graphics shall be printed on the sign, or otherwise permanently affixed to the sign. See Figure 10 for signage specifications.



(Minimum 1/2 inch stroke for all text)

FIGURE 10 - SIGNAGE SPECIFICATIONS

The layout or arrangement of the required signage features is flexible. See Figure 11 for examples of acceptable arrangements.

FIGURE 11 - OTHER ACCEPTABLE SIGNAGE ARRANGEMENTS

Facilities capable of, but not utilizing high pile storage. Signage used in areas capable of, but not practicing high piled storage shall be the same dimensions, color scheme and wording with one exception. The red stripe does not contain any wording and is left as a solid red stripe. This allows the signs to be used when the area is used for high pile storage by affixing the proper wording to the red stripe.

Signs shall also be constructed of durable materials such as metal or plastic. Signs constructed of paper, cardboard or similar materials are not acceptable. All graphics shall be printed on the sign, or otherwise permanently affixed to the sign. See Figure 12 for an acceptable example.

Striping. An acceptable alternative to signage is striping. The striping shall consist of a 3 inch solid red stripe running the entire perimeter of the area. The red stripe shall have 2 inch white wording having at least an 1/2 inch stroke. Figure 13 depicts an illustration of the striping design; however, does not show the acceptable required wording.

FIGURE 12 - STRIPING DESIGN EXAMPLE

For areas with high pile storage, required wording shall state "NO STACKING ABOVE THIS LINE BY ORDER OF RFD". The greatest commodity classification and maximum storage height permitted shall also be provided. All wording shall be oriented as shown in Figure 14. Wording shall be spaced at 50-feet intervals as measured from end of wording to start of wording as depicted in Figure 15.

FIGURE 13 - ACCEPTABLE ORIENTATION OF REQUIRED WORDING

FIGURE 14 - REQUIRED STRIPE WORDING AND SPACING EXAMPLE

For areas capable of, but not practicing high pile storage, the only acceptable form of stacking limit identification is the approved signage mentioned above. Striping is not permitted.

SIGNAGE AND STRIPING INSTALLATION REQUIREMENTS

All high pile combustible storage areas and those areas capable of, but not practicing high pile storage, are required to install applicable signage at the maximum permitted height of the storage. The signage is designed to provide a visual indicator that storage must not exceed a certain height. If storage exceeds permitted heights, a resulting fire could very easily and quickly overtake a sprinkler system (if present) because along with other variables, the sprinkler system is specifically designed for a given height of storage. Storage exceeding permitted heights in unsprinklered buildings presents a significant hazard for firefighters as the height of the storage affects the penetrability of fire hose streams. Therefore, it is extremely important for the designed storage height permitted within a storage area to remain at that height. Storage heights not in compliance may be the difference between a single pallet fire and a complete building loss.

All signage and striping must be installed to provide maximum visibility. The top of the red stripe, whether on signage or striping alone, shall be installed at the maximum storage height permitted as measured from the floor. See Figure 16.

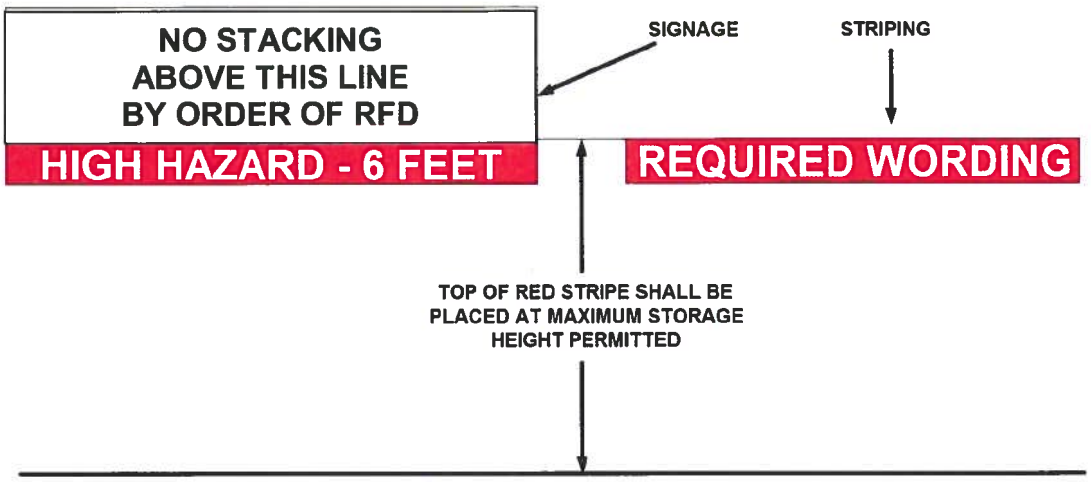


FIGURE 15 - SIGNAGE AND STRIPING VERTICAL INSTALLATION EXAMPLE

Signs shall be placed a maximum of 25 feet from all corners within a storage area, and shall be spaced a maximum of 50 feet between signs along perimeter walls of the storage area. Signage may be adjusted to provide enhanced visibility while not exceeding the maximum distances. For example, depending on the layout of aisles, signage may be adjusted so that the sign is centered on the aisle. See Figures 17-19.

Internal portions of the storage area shall be signed or striped, as well. If columns are available, signs may be mounted to the columns in such a way as to provide maximum visibility. This may include providing signs on more than one side of the column. Striping shall encompass all applicable columns. When columns are not present, the signage may be hung from the roof supports. These signs would be provided at the required spacing.

If the spacing of the columns is greater than 50 feet, signs or striping shall be provided for all applicable internal columns. When column spacing is less than 50 feet, signs or striping shall be provided on all applicable columns not to exceed 50 feet spacing. See Figure 18 for an illustration.

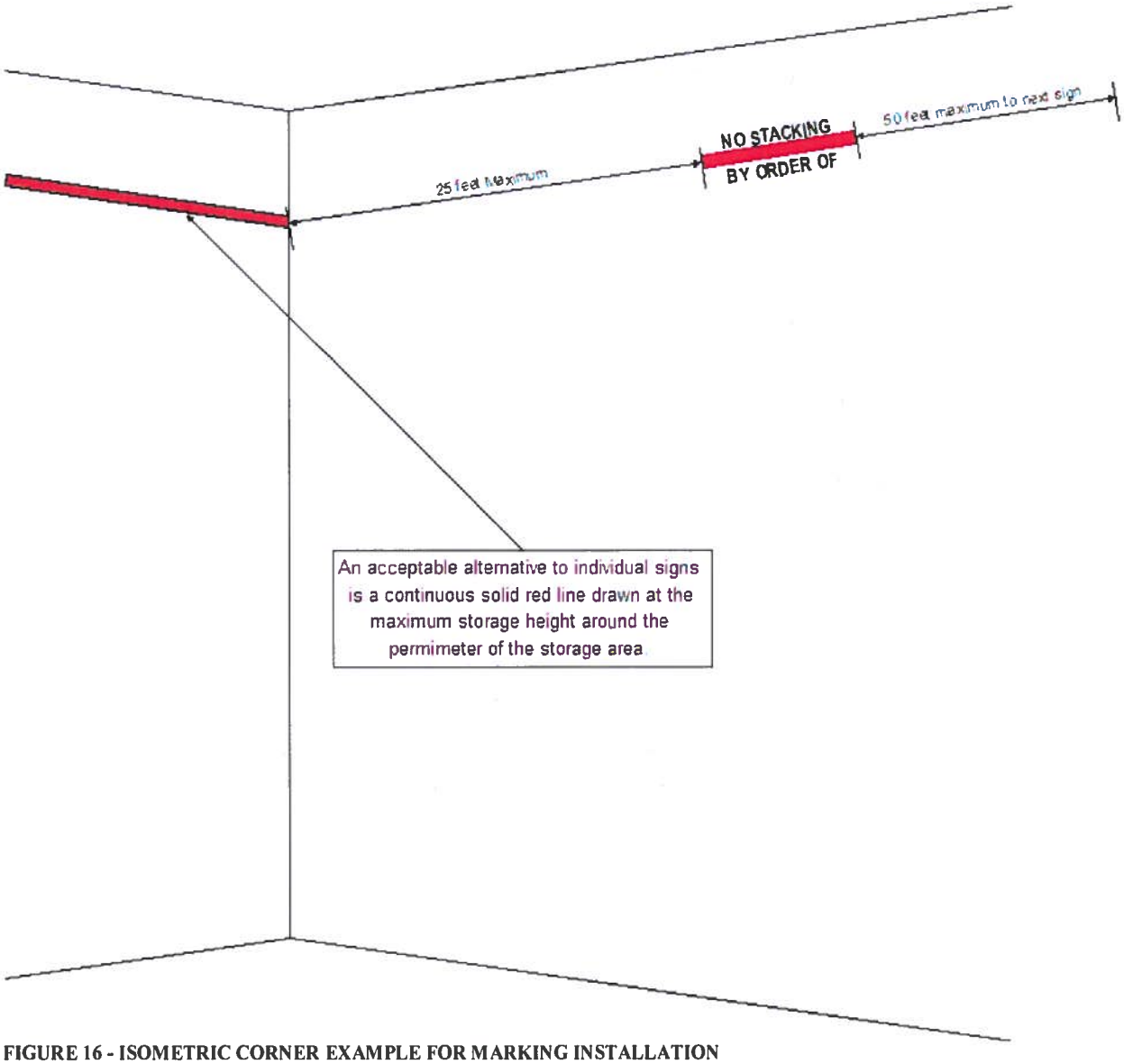


FIGURE 16 - ISOMETRIC CORNER EXAMPLE FOR MARKING INSTALLATION

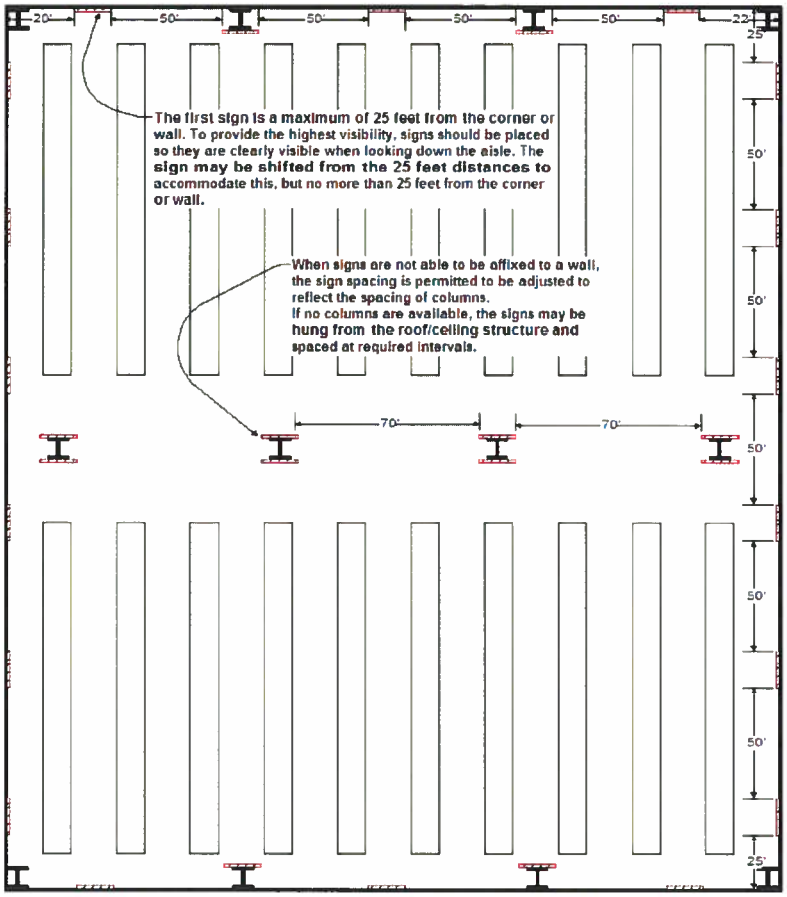


FIGURE 17 - SIGNAGE PLACEMENT AND SPACING EXAMPLE

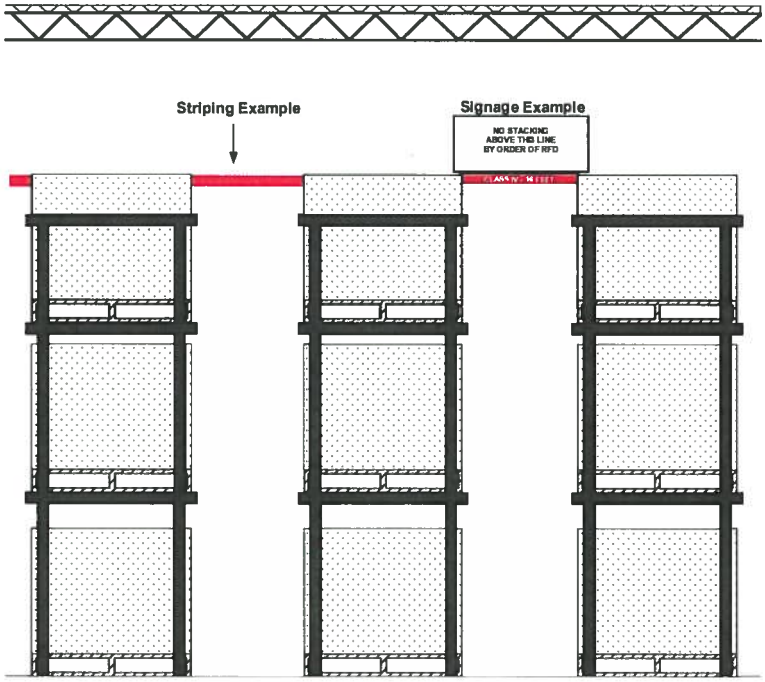


FIGURE 18 - END OF AISLE VIEW OF SIGNAGE AND STRIPING PLACEMENT EXAMPLE

COMPLETING THE HIGH PILED STORAGE APPLICATION FOR NEW BUILDINGS OR TENANTS

General Storage (Class I-IV Commodities)

Completely and accurately fill out the High Pile Combustible Storage Application. The application should be completed and signed by a person qualified to answer these questions correctly. The following is a breakdown of each section of the questionnaire and commentary explaining the information being sought.

Company Name. Please provide the name of the tenant/business which will be occupying the space intended for stocking of high piled combustible materials.

Company Address. The correct and complete address must be provided to insure the correct information is in our database and on the high piled combustible storage permit.

Business Telephone. Provide at least one daytime phone number for the business that can be used as a contact for any questions or concerns. If possible, include a fax number and a secondary number.

Item 1. **Commodity Classifications.** Identifying commodity classifications is the first step in determining applicable fire code requirements. Fire protection measures, such as fire sprinkler designs, are also based on commodity classifications. If a commodity is misclassified and fire sprinkler systems are designed for the incorrect classification, a resulting fire may easily overtax the sprinkler system causing the sprinkler system to be ineffective. Therefore accurately classifying commodities is imperative. It is understood that difficulties may arise in trying to determine appropriate classifications. Document 2 provides a comprehensive listing of various commodities, with their classifications. If difficulties are still being experienced, please contact the Fire Prevention Division for assistance.

Item 2. **Description of Storage.** Provide an accurate and detailed description of all current storage practices in the facility. If commodity classifications are known, provide descriptions of where and how each classification is being stored. For example, Class I commodities being stored throughout the facility; Class IV commodities being stored on racks A-E to heights of 22 feet. and Class III commodities being stored on racks F-J to heights of 15 feet.

Item 3. **Maximum Storage Height.** Provide the maximum height(s), in feet, of the storage within the facility. This measurement is taken from the floor to the **top** of the stored commodity, not to the highest shelf or rack.

Item 4. **Maximum Ceiling Height.** This is the measurement, in feet, from the floor of the high piled storage areas to the bottom of the roof deck.

Item 5. **Method of Storage.** Indicate all methods in which commodities are currently being stored. Photographs, specification sheets and other information may be submitted to provide a better understanding of how commodities are being stored.

Item 6. **Rack Storage Information.** Provide as detailed and accurate information as possible.

Type of Racks. (NOTE: RACK INFO TYPICALLY SUBMITTED WITH RACK PLANS) Single row racks are those racks in which commodities may be reached from either side of the rack. No flue space is located in the middle of single row racks. Double row racks allow access from a single side of the individual rack, with a flue space in between the racks. See Figure 19. Multiple row racks are similar to double row racks,but incorporate more than two racks. Multiple row racks will be more than two pallets deep.

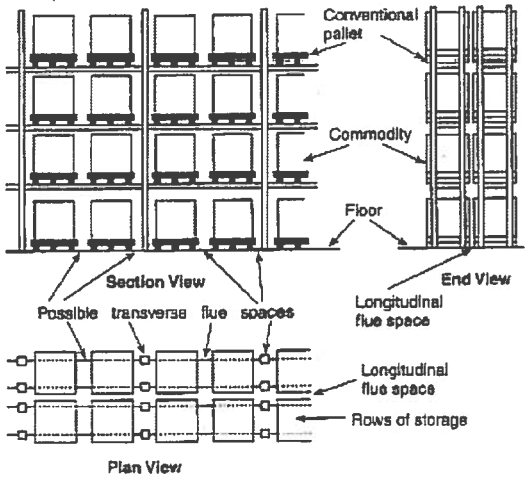
Height of Racks. Indicate if racks are "x" ft high in one area and "y" ft high in other areas or a constant height throughout. This measurement is from the floor level to the highest possible level or shelf the racks. Rack specification sheets may be submitted, as well.

Depth of Racks. This measurement is from the front of the rack or aisle, to the back of the rack either aisle (for single row racks) or flue space (for double and multiple row racks). If different width racks are present, indicate all widths of all racks. For double or multiple row racks, indicate the total widths (depths) of each double or multiple rows.

Width of Racks. This is the side-to-side measurement of the racks. Provide the total width of the racks for each row. The width measurement is measured parallel to the aisles.

Aisle Widths Between Racks. Typically the aisle widths will be either 4 or 8 feet wide. However, other aisle widths are definitely possible. Indicate the smallest dimension on the questionnaire, but be sure to show all aisle widths on the drawings. See Figure 20.

Longitudinal and Transverse Flue Spaces. Indicate both of these flue spaces in inches for the current storage practices in the facility. See Figure 19.



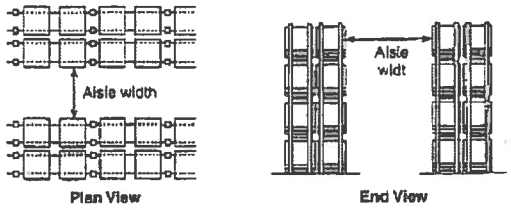


FIGURE 19 - TYPICAL DOUBLE ROW RACK WITH FLUES FIGURE 20 - ILLUSTRATION OF AISLE WIDTH

Item 7. **Smoke Vents.** Based on the requirements of Chapter 23 in the 2010 CFC, determine if smoke vents are required.

Vent to Ceiling Area Ratio. Once smoke vents are required, the applicable vent to ceiling ratio must be determined. Table 910.3 (below) taken from the 2010 CFC provides the available ratios based on the situation.

Number of Vents Required. Provide the total number of vents that are required based on the vent to ceiling area ratio chosen.

Item 8. **Draft/Curtain Boards.** Indicate if draft or curtain boards are being proposed.

Item 9. **Gross Square Footage of Entire Structure.** Provide the gross square footage of the entire facility. This figure includes all portions of the structure, as well as each individual floor, mezzanines, etc.

Item 10. **Square Footage of High Piled Storage Areas Only**. Provide the square footage for all areas used for the high piled storage of combustibles. If more than one area is present and the areas are separated in some fashion (either by distance or barrier) indicate the sizes for each area. If more than one area is present and not separated in some manner, sum all areas into one

area. For those areas that are separated, indicate this with a number in the check box next to the appropriate size for each area. Otherwise, check the appropriate box. The areas used in this measurement are all floor spaces being used by racks and/or piles, plus the required aisles for each area. A general rule of thumb for numerous rows of racks or piles is to include all aisles between the racks and piles, as well as any applicable required aisles elsewhere throughout the storage.

Item 11. **Fire Sprinkler Design Density.** Indicate if the design density of the fire sprinkler system for all storage areas.

Item 12. **Piled Storage Information.** Provide as detailed and accurate information as possible. This section only refers to commodities being stored on the floor (with or without the use of pallets) and stacked atop each other. No racks or shelves are used for pile storage.

Cubic Feet Per Pile. Provide the cubic feet for each high pile of combustible storage.

Maximum Pile Dimension. This measurement represents the longest side of a pile.

Maximum Pile Height. As measured from the floor to the top of storage in feet. If multiple piles with different heights are present, provide information for all piles.

Aisle Widths Between Piles. Typically the aisle widths will be either 4 or 8 feet wide. However other aisle widths are definitely possible. Indicate the smallest dimension on the questionnaire but ensure to show all aisle widths on the drawings. See Figure 20.

Item 13. **Access Doors Provided**. - Access doors providing access from the exterior roadways and/or driveways directly into the high piled storage areas is what may be required. An exterior door that provides direct access into the high piled storage areas from a sidewalk does not meet this criterion. An access door from a roadway into an office which is adjacent to the high piled storage area also does not meet this criterion.

Item 14. **Access Doors Keyed for Fire Department Use**. All access doors specifically into the high pile storage areas must have a method for gaining entry from the exterior of the facility. In the very least, a key lock must be present with the master key(s) located in the facilities' Knox™ box.

Knox™ Box Note. All warehouse facilities with fire detection/alarm and suppression systems installed require a Knox™ Box system installed in a fire department approved location. The Knox™ system is a safe and secure on-site key box for the fire department's use only. The Riverside City Fire Department has sole access to the Knox™ box. Master keys, card keys and any other special access

keys (to any fire protection system) are required in the Knox™ box. This permits safe entry and limited damage into your facility in the event of an emergency. Each exterior door should have a Knox™ system label installed to assist the fire department in recognizing that the building is equipped with this system.

Names and Titles of Persons Responsible for Information Contained Within Application. Provide the names of the individuals who completed these forms, along with all applicable phone/fax numbers, in order to contact them for additional information, or to answer questions that may arise.